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THE Apparatus for Schools and Families, devised and prepared by Mr. JOSIAH HOLBROOK, several years since, and extensively used in this and other countries, has recently been much improved. It provides large and varied exercises for the eye and hand, in practical lessons on the laws and works of our Creator; and thus secures the most solid improvement for the pupil, while producing visible, tangible, portable illustrations, instructive to all human beings—alike to the unlettered savage and accomplished scholar. They hence promote the diffusion of knowledge, as the most sure and effectual mode of individual improvement.

Before these articles appeared, which was more than twenty years since, Apparatus was in use in Colleges, and to some extent in Academies and High Schools, but of such expensive character that it was entirely beyond the reach of Common Schools; indeed, very little of it was designed to illustrate those branches taught in common schools.

'Tis true, that globes could be had for ten dollars, and more; that planetariums were constructed at an expense of hundreds or thousands; that air-pumps and electrical machines were imported for colleges, and rarely for academies; it yet remained to bring Apparatus within the reach of the million; first, by devising instruments adapted to the grade of studies pursued in common schools; and secondly, to

construct them in so inexpensive and durable a manner as to bring them within the means of the poorest district in the country.

How well this has been accomplished, the hundreds and thousands of district schools already supplied can testify where, before the introduction of "HOLBROOK'S APPARATUS," the *Ferule* and the *Gad* were the only available articles of apparatus in the hands of the teachers.

USES.

The following are its uses:

First—It employs, entertains and instructs children, before they understand or are able to comprehend the *arbitrary signs* of ideas in books; and thus aids and relieves the parent, while it benefits the child.

Second—It changes the long and irksome, because unnatural process of teaching children to read, write and spell, into agreeable, instructive exercises, and thus produces better readers, writers and spellers, in far less time. In Prussian Schools, after a course of lessons entirely on objects, *one week* is a common time for a pupil to learn to read simple sentences.

Third—It gives correct and clear *first impressions*, and hence avoids the laborious and painful task of *unlearning* error, and of groping in darkness, or obscure light; also removes the evil of *forgetting* after many repetitions.

Fourth—It increases a love of learning, of books, and of school; and hence, cures truants, promotes assiduity and good order in pupils, and secures their continual improvement, after closing their school education.

Fifth—It affords an early, exact, and varied exercise and training of the eye and hand, with and for the mind, and thus promotes manual skill, sound judgment, and *habits of*

industry, while it gives larger, richer and more durable mental treasures.

Sixth—It gives children employment at their homes; and thus renders them orderly, happy and entertaining to each other, to their parents and other friends.

Seventh—It enables pupils to aid each other in their studies, and to strengthen the hands of their teacher; and thus advance their own improvement, and elevate or sustain the character of their school.

Eighth—It promotes a pleasant and profitable reciprocation between the family and school, and thus enables parents and teachers to aid each other in an object alike interesting to both.

Ninth—By a taste thus promoted, for the pleasures of science, and with it a conscious dignity from diffusing those pleasures and blessings widely among nations, a security, nearly certain, is provided against pleasures of a low and degrading character, now ruining thousands, and threatening our liberties and our republic.

Tenth—As one set of apparatus is sufficient for a family or school for a series of years, economy, or the saving of expense, added to the more and better instruction with higher motives, commends it to the special attention of parents, teachers, school superintendents, and all others interested in a sound, Christian and Republican education.

The set embraces, for Geography, a Globe, a Hemisphere Globe, a Tellurian and Planetarium. Though a five-inch Globe, it illustrates the shape, position, motions, divisions, and other prominent features of our earth, far more simply, correctly and effectually, than one of twice the size and ten or fifteen times the expense.

For Geometry, are diagrams and solids, showing the figures, names, properties and uses of this simple, practical

science; fitted before and more than anything else perhaps, to employ young hands and interest young minds.

Illustrations by all the above articles are presented directly to the eye and memory, and of course ought to precede the *abstractions* of number, and the *arbitrary* signs of knowledge in books, words and letters.

For Arithmetic, is a Numeral Frame, with moveable balls, or counters, to illustrate *practically*, numeration, addition, subtraction, multiplication, division, fractions, and the squares and roots of numbers.

Also, a Sectional Block, for the illustration of the extraction of the cube root.

For the whole, is a Manual of Explanations and Questions, to render their various uses plain, simple and interesting, not only to parents and teachers, but to pupils of all ages.

The articles are all safely packed in a box, fitted for transportation to any distance.

OBJECTIONS.

These objections are often presented against the purchase of apparatus:

First objection.—"We are not able to purchase apparatus. Our school costs us now more than we can afford to pay."

Answer.—As well might the farmer say, I can't afford to buy a fanning mill, or adopt any other improvement, which, by saving time and labor, soon pays for itself.

The very end that apparatus aims at, is to save time, labor and expense; and this it never fails to do, in the hands of any teacher who is worthy to be intrusted with the education of children. If a teacher does not know enough to make use of these simple means of illustration in the

branches in which he is engaged daily, it may safely be inferred that he does not know enough to teach them at all. If a mechanic is unable to pursue his calling when provided with suitable tools, it is hardly to be expected that he will accomplish much when destitute of them.

Objection second.—"I have not time to use apparatus. I have more to do now than three men can do."

Strange as it may seem, this objection has been offered, time and again, by teachers themselves.

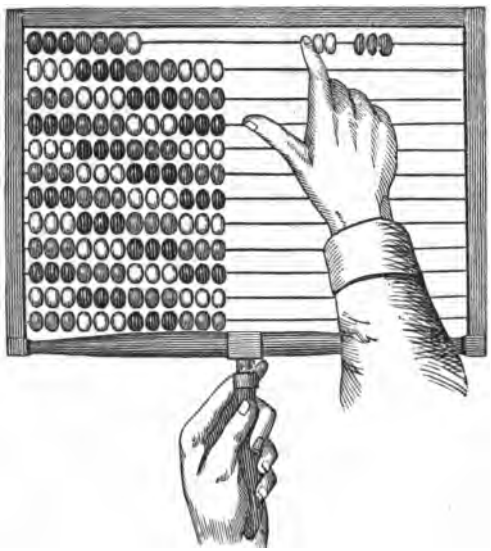
Answer.—You would not probably have time to step on board of a steamboat or railroad car, if you had three days travel to perform in one; you would surely make your journey on foot.

Or, more directly. If the different branches are to be taught so as to be understood, will it require more time to give the necessary explanations and illustrations, with the appropriate apparatus, which brings out the difficult and obscure points in so simple and clear a light that the dullest see and understand at once?

Objection third.—"The apparatus, if purchased, will soon get broken to pieces and destroyed."

Answer.—Deliver the apparatus into the hands of your teacher, and make him responsible for its safe keeping, after having provided a case with a lock and key, suitable for containing it. [See dimensions of the case as furnished by the agent.] If he is unwilling to be responsible for apparatus of small value, furnished for his especial aid and accommodation, he is certainly unfit to be intrusted with the care of that which is beyond all price, the minds, manners and morals of his pupils.

ARITHMETIC.



NUMERAL FRAME.

With regard to no other article of illustration for Common Schools, is there so great diversity of opinion among teachers. While some think it of no use, as they can make marks on the black board, (which, by the way, they never do,) for illustration; while some think it will do for the primary classes in learning to count, many others consider the Numeral Frame an indispensable article in every stage of Arithmetic, as well as applicable to Chemistry and Natural Philosophy. And the more they use it, the more uses they find for it. The main object of this, as of any other visible illustration, is to assist the mind, particularly the undisciplined mind, in forming clear and distinct conceptions of principles.

A child may, for instance, repeat again and again, for months, "The Earth is round like a ball," or "The Earth is a Globe or Sphere," and yet be entirely ignorant of the fact embodied in the language. But what child can see a globe, and have his country pointed out to him, and as nearly as may be, his own place of residence on that globe, and not know and understand the fact? So a child may repeat the Addition Table, "six and three are nine," and yet remain entirely ignorant of the fact, or the Multiplication, "three times five are fifteen, four times five are twenty," obtaining as much mathematical knowledge as from one of Mother Goose's melodies, "Hi diddle diddle, the cat's in the fiddle," etc.

The proper use of the visible counters of the Numeral Frame will, infallibly, break up the sing-song of tables, and impress immutable truths on the mind of the pupil.

Some little adaptation, some little expense to obtain an object is by no means lost either, on a course of instruction. Colleges may go to the expense of hundreds or thousands for the purpose of illustrating and impressing a truth of not one hundredth part the practical value of one of those involved in the powers and relations of numbers, and who objects? No one. It is money well laid out. These sophomores or seniors are, undoubtedly, enough better taught to warrant the expense. But many a parent, and teacher too, thinks and says, my children or scholars can just as well use their fingers, or kernels of corn, or marks on the black board, as to go to the expense of a dollar for an instrument, which, by its adaptation, its novelty, its variety of application, is calculated to arouse the stupid, enliven the dull, stimulate the sluggard, and shed new light and interest over the fundamental principles of the most important of all sciences.

The uses of the Numeral Frame, in the fundamental

rules, are so obvious as hardly to require any particular explanation, farther than a few questions, which will be found appended to this article.

I shall, however, throw out a few suggestions, as to its applications in fractions, the most obscure department of Arithmetic, because the pupil, here, is compelled to deal most in abstractions. Now there is no case, however complicated, in fractions, but can be illustrated clearly by the Numeral Frame.

I will take one or two examples:

1. The value of fractions as depending on the denominator, diminishing as the denominator increases, the numerator remaining the same. As there are units of different kinds, denominations, and values, and every unit may be taken as a fraction of some other unit, and every fraction may be considered a unit independent of any other fraction or unit, let us consider the twelve balls on a wire a unit. Divide one such unit into halves, another into thirds, another into fourths, another into sixths, and another into twelfths. Present these units, so divided, to the class, with questions such as the following: How many halves in a unit? How many thirds? Which unit is divided into halves, which into thirds? How many quarters, etc.? Which is the largest or worth the most, a half or a third, a quarter or a sixth, a sixth or a twelfth? A seventh or an eighth? Repeat and vary such questions, until every member of the class fully understands how the value of a fraction is effected by the denominator, and why.

2. The addition of fractions:

For example, take two thirds and three quarters, as fractional quantities to be added. They neither make five thirds nor four quarters; what do they make? We cannot add them in the form of thirds and quarters, any more than we can add two shoulders and three hams together. But, as in

the case last mentioned, we can find some common unit, as a pound, and ascertain the quantity of meat in the whole, so in the former case, we can easily find a common fraction, viz: a twelfth, which happens to be a ball, and finding how many twelfths, in each of the fractions, of both kinds, we can add them, two of one kind, and three of the other, and thus obtain a result at once correct and pleasing to the scholar, who has long blundered over the "rules of fractions."

Every difficulty in fractions, or in proportion, or in allegation, in squares and square roots, can be elucidated with equal facility.

I am fully aware that there is a class of teachers who will reject such modes of illustration, just because they are "so simple," who prefer dealing with abstractions, in an abstract manner, and throwing an air of mystery and dignity around themselves by surrounding the simplest truths of science with obscurity, as if whatever is muddy must be deep.

QUESTIONS ON NUMERAL FRAME.

How many are one and one—two and two—three and one—four and one? If one be taken from one, how many? One from two—one from three—two from three? &c. Questions like the following give great facility in combining numbers:—Seven and five, how many—seventeen and five twenty-seven and five—thirty-seven and five? &c. Nine and seven, how many—nineteen and seven—twenty-nine and seven?—extending it to ninety-nine and seven. Applying this exercise to a great variety of combinations, carrying each from the elementary digits up to a hundred, renders the pupil expert in practical Arithmetic.

How many are once one? How many are twice one? How many ones in two? Two. What part of two is one?

One half. How many are half of two? One. How many are two twos? Four. How many twos in four? Two. What part of four in two? One half. How many are half of four? Two. How many are three twos? Six. How many twos in six? Three. What part of six is two? One third. What part of six is two twos, or four? Two thirds. How many thirds of six are three twos? Three. What part of six is three thirds? The whole.

How many are four twos? Eight. How many twos in eight? Four. What part of eight is two? One fourth, or a quarter. What part is two twos, or four? Two fourths. What part of eight is two fourths? One half. What part of eight is three twos, or six? Three fourths. How many fourths of eight are four twos? Four fourths. What part of eight is four fourths? The whole.

How many are five twos? Ten. How many twos in ten? Five. What part of ten is two? One fifth. Two twos? Two fifths. Three twos? Three fifths. Four twos? Four fifths? Five twos? Five fifths. What part of ten is five fifths? The whole. How many are a fifth of ten? Two. Two, three, four and five fifths?

How many are six twos? Twelve. How many twos in twelve? Six. What part of twelve is two? One sixth. Two twos? Two sixths. Three twos? Three sixths. Four twos? Four sixths. Five twos? Five sixths. Six twos? Six sixths. How many are one sixth of twelve? Two. Four sixths? Eight. Three, four, five and six sixths? What part of twelve is six? One half. Four? One third. Three? One fourth.

How many are seven twos? Fourteen. How many twos in fourteen? Seven. What part of fourteen is two? One seventh. What part is two twos? Two sevenths. Three, four, five, six and seven twos? How many are one seventh of fourteen? Two. Two sevenths? Four. How

many are three, four, five, six and seven sevenths? What part of fourteen is seven? One half.

How many are eight twos? Sixteen. How many twos in sixteen? What part of sixteen is two? Also, four, six, eight, &c. How many are one eighth of sixteen? Two, three, four, &c. eighths? What part of sixteen is eight? One half. A fourth and three fourths? What part of sixteen is four, eight, and twelve?

How many are nine twos? Eighteen. How many twos in eighteen? Nine. What part of eighteen is two? One ninth. Two twos? Three, four, five &c. twos? How many nines in eighteen? Two. What part of eighteen is nine? What part is six? One third. Three? One sixth.

How many are ten twos? Twenty. How many twos in twenty. Ten. What part of twenty is two? How many fives in twenty? Four. What part of twenty is five? One fourth. How many fours in twenty? Five. What part of twenty is four? One fifth.

How many are three ones? Three. How many ones in three? How many are the third of three? One. Two thirds? Two. Three thirds? Three. What part of three are three thirds? The whole. How many are two threes? Six. How many threes in six? What part of six is three? How many are one half of six?

How many are three threes? How many threes in nine? How many are a third of nine? Three. Two thirds? Six. Three thirds? Nine. The half of nine? Four and a half. What part of nine is three? One third. Six? Two thirds. What part of nine is three thirds? The whole.

How many are four threes? Twelve. How many threes in twelve? Four. What part of twelve is three? A fourth. What part is four? A third. Which is the most,

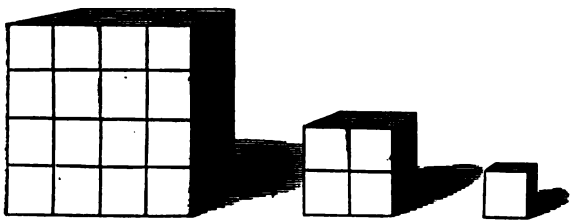
the third or the fourth of twelve? The third. How many more is a third than a fourth? One. How many are a third of twelve? Four. Two thirds? Eight. A fourth? Three. Two fourths? Six. Three fourths? Nine.

How many are five threes? How many fives in fifteen? Three. What part of fifteen in five? A third. What part of fifteen is six? Two fifths. What part is ten? Two thirds. Which is the most, a third or a fifth of fifteen? A third. How many the most? Two.

How many are once one? One. Twice two? Four Three times three? Nine. Four times four? Five times five? Six times six? Seven times seven? Eight times eight? Nine times nine? Ten times ten?

What number multiplied by itself produces one? One. What is the square of one? What number multiplied by itself produces four? Two. What is the square of two? Four. What the square root of four? Two. What number multiplied by itself produces nine? Three. What is the square of three? Nine. What the square root of nine? Three. What number multiplied by itself produces sixteen? Four. What is the square of four? Sixteen. The square root of sixteen? Four. What number multiplied by itself produces twenty-five? Five. What is the square of five? Twenty-five. What is the square root of twenty-five? Five. What number multiplied by itself produces thirty-six? Six. What is the square of six? Thirty-six. The square root of thirty-six? Six. Of what numbers are seven, eight, nine and ten the square roots?

By such questions, greatly extended and varied, at first aided by the Numeral Frame, the pupil becomes so strong and familiar in the whole ground-work of numbers, in all their departments, as to act intelligently, *not by guessing*, in any question he may be called to solve.



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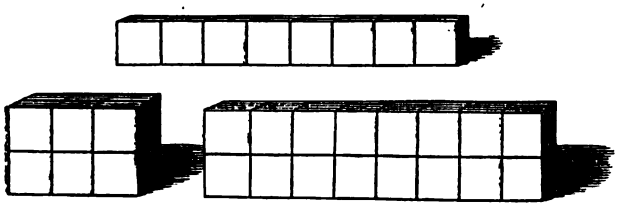

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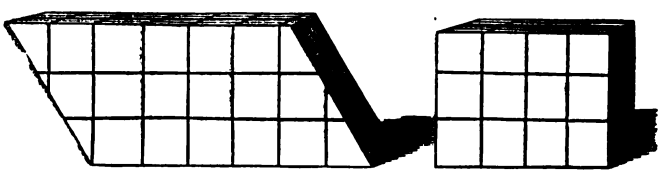

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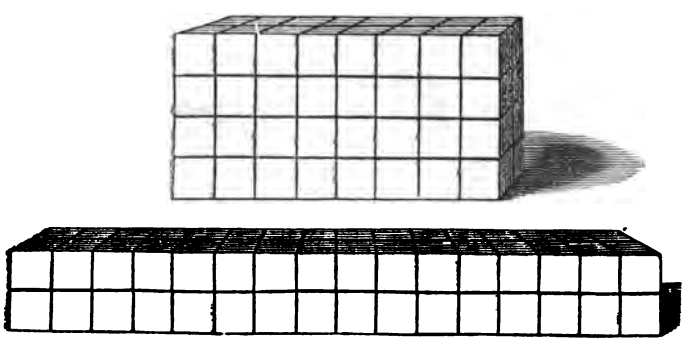

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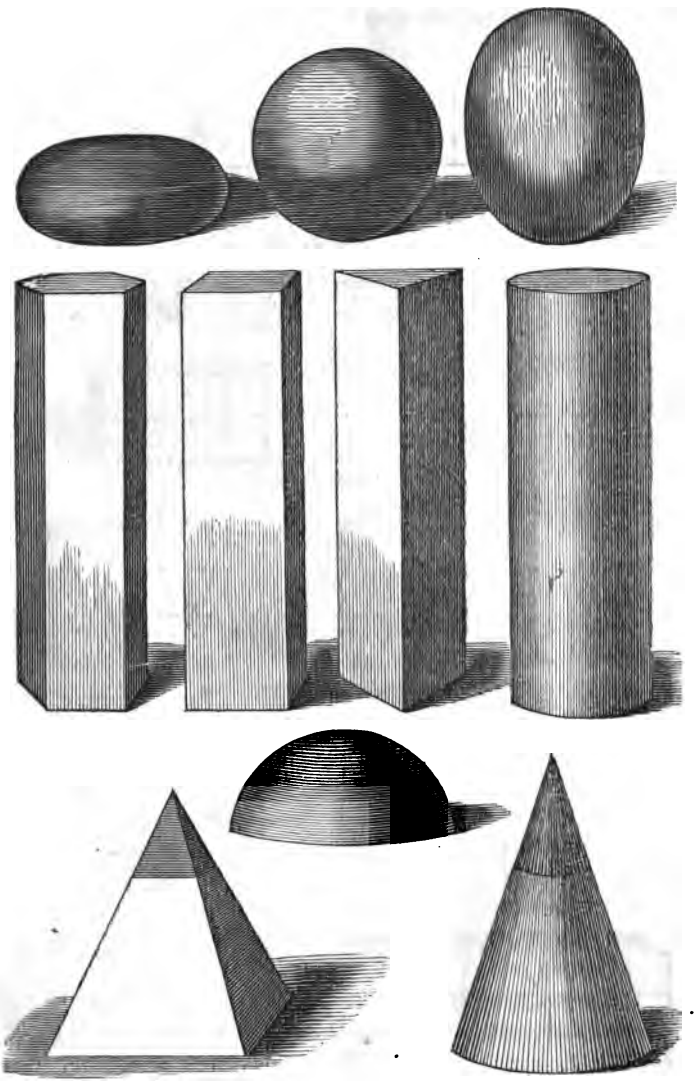
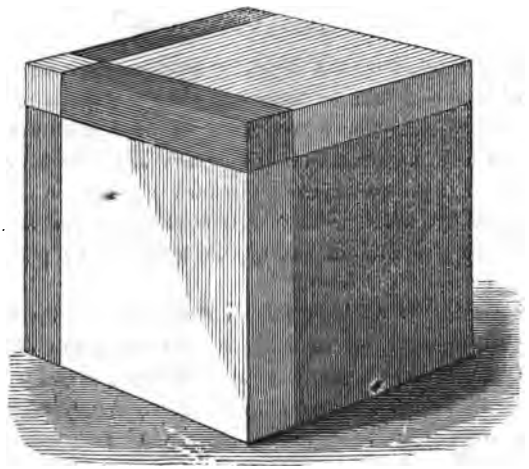
GEOMETRICAL FORMS.



GEOMETRY.



GEOMETRICAL SOLIDS.

Geography describes, Geology analyzes, and Geometry measures the earth. This three-fold science is useful to every person on earth, and furnishes interesting lessons for children before they can comprehend the *arbitrary signs* of knowledge in books.

By a globe, tellurian, and maps for Geography, a cabinet of minerals for Geology, and diagrams and solids for Geometry, a child of three years can understand the shape, divisions, and ingredients of the earth, as thousands who have tried it know; many of whom also know that the long and irksome task of learning to read thus becomes a short recreation.

The first idea of our earth given by a globe, is that it is round, or its geometry. Hence a sphere and oblate, a pro-

late spheroid, with a cube, cylinder, cone, and other Geometrical Solids, ought to precede, or accompany the globe for children.

GEOMETRICAL DIAGRAMS

Can be learned from a sheet, by forming them on a slate, both of which should be furnished for every child of three years old, whether in school or at home. With the sheet upon the wall, and the slate and pencil in the hands of the child, he will commence and pursue his lessons in *drawing* and geometry, by constructing triangles, squares, and circles, not to the burden, but to the relief of the parent or teacher.

Many children have in this manner, not only learned to draw, but to write, by imitating the names of the different figures, as printed on the sheet, and by drawing and writing, learned the letters and their uses and powers in the formation of words and sentences. They have thus learned to read.

GEOGRAPHY.

The best method ever yet devised for teaching Geography, is unquestionably that denominated the "Topic System."

This method takes for granted, not only a systematic arrangement of topics, by which to study any given country or political division, but a classified view of the entire subject matter of Geography; and it is further supposed, that every teacher will make himself thoroughly acquainted with such a classification, before he shall attempt to use the Topic System in his course of instruction.

This general outline of the Science of Geography, in its different departments, can then be given in suitable portions

on the black board, by the teacher, with definitions and explanations, and copied into note books by the scholars, who will afterwards, in succession, from day to day, present it *without notes* on the black board, *with* definitions and explanations, subject to the criticism of the class and the teachers.

Two or more departments may be assigned to as many pupils for each day's recitation, until every scholar shall have given the whole satisfactorily. In order to economize time, one scholar, or the class at large, may be engaged in reciting the topics as applied to the country, before assigned for a lesson, while two or more are writing their exercises on the black board.

Outline Maps, a Globe and Tellurian, are indispensable for the highest success of the Topic System, as well as for thorough instruction by any method whatever.

For the purpose of assisting teachers, who may not otherwise be able to avail themselves of this system, I shall insert a general outline of the science, as well as a more definite arrangement by which to study the Geography of any particular country, state, or kingdom.

It will be perceived that this method does not require a uniformity of text-books; but makes a diversity desirable, rather than otherwise.

Farther, the plan admits of almost endless variety in the course of procedure, giving ample scope for the ingenuity and skill of the teacher, in awakening and sustaining interest, and in imparting thorough and varied instruction.

GENERAL OUTLINE.

GEOGRAPHY,
1. Mathematical.
2. Physical.
3. Civil.

MATHEMATICAL GEOGRAPHY.

1. Position of the Earth.
- Third Planet in the Solar System.
- Distance from
  - Sun, 95 millions.
  - Moon, 240 thousand.
  - Other Planets, variable.
  - Nearest Fixed Star, 60 trillions.

} Illustrated by Planetarium.

2. Form.
- Proofs that the Earth is Globular.
  1. Circumnavigation.
  2. Appearance of ship at sea.
  2. Shadow on the Moon.
  4. Appearance of Pole Star.
  5. Appearance of Clouds in horizon.
  6. Suspended Weights.
  7 Force of Gravity.
  8. Analogy.
  9. Actual Measurement.
- Proofs that the Earth is an Oblate Spheroid.
  1. Varying Vibrations of Pendulum.
  2. Measurement of degree of latitude.
  3. Centrifugal Force.
  4. Analogy.

} Illustrated by Planetarium.

3. Magnitude.
- Diameter.
  - Equatorial, 7,924
  - Polar, 7,898
  - Mean, 7,912

  } Difference, 26 miles.
- Circumference, 25,000
- Area, 197,000,000

} Square miles.

4. Motions and Velocities.
1. Diurnal—1,000 miles per hour at Equator.
2. Annual—68,000 " " in Orbit.
3. In common with the Solar System, 35,000 miles per hour.

} Illustrated by Tellurian and Planetarium.

5. Lines and Divisions.
1. Diameter.
2. Axis.
3. Circumference.
4. Equator.
5. Tropics.
6. Polar Circles.
7. Parallels of Latitude.
8. Meridians of Long.
9. Zones.
10. Hemispheres.

} Measured by the Divisions of a Circle.
- Degrees.
- Minutes.
- Seconds.

6. Methods of representing Shape, Surface and Relations.
- Globe.
- Lunarian.
- Tellurian.
- Planetarium.
- Maps and Charts.

7. Phenomena.
1. Day and Night.
2. Where a Day commences.
3. Difference of Time.
   - Absolute.
   - Relative.
4. No absolute UP and DOWN.
5. Change of Sun's declination.
6. Rising and setting of the Sun north of east and west, in summer.
7. Change of Seasons.
8. Eclipses.
9. Tides.
10. Changes of Moon.
11. Precession of Equinoxes.

} Illustrated by Globe and Tellurian.

PHYSICAL GEOGRAPHY.

- **1. Structure.** — Geology, Mineralogy — Illustrated by Cabinet of Minerals.
- **2. Land.**
  - Divisions — 1. Continents. 2. Islands. 3. Peninsulas. 4. Isthmuses. 5. Capes. 6. Promontories.
  - Surface —
    - Mountains — 1. Ranges. 2. Systems. 3. Groups. 4. Peaks. 5. Volcanoes (Active. Dormant.)
    - Hills, Valleys, Plains —
      - High — Prairies in U. S. Pampas in S. A. Steppes in Asia.
      - Low, Fertile,
      - Barren — Sandy. Salt.
- **3. Water.**
  - Oceans and Seas considered in respect to — 1. Extent. 2. Depth. 3. Temperature. 4. Color. 5. Taste. 6. Motion. 7. Uses.
  - Lakes (Salt. Fresh.) — 1. With Inlets and Outlets. 2. " Inlets and no Outlets. 3. " Outlets and no Inlets. 4. " neither Inlets nor Outlets.
  - Gulfs and Bays.
  - Straits.
  - Rivers, etc. etc. — 5. Subterranean. 6. Periodical.
- **4. Climate considered in respect to**
  - 1. Temperature.
  - 2. Moisture.
  - 3. Salubrity.
  - 4. Circumstances modifying — 1. Latitude. 2. Elevation. 3. Proximity to body of Water. 4. Aspect of Country. 5. Nature of Soil. 6. Degree of Cultivation. 7. Vicinity of Mountains. 8. Direction of Declivity. 9. Prevailing Winds.
- **5. Soil.** — 1. Calcareous, 2. Silicious, 3. Aluminous, 4. Loamy, 5. Alluvial, — Fertile. Sterile.
- **6. Productions.**
  - Minerals — Ores. Building Materials. Fuel. Precious Stones, etc. etc.
  - Vegetables — Food. Building Materials. Fuel. Dye Stuffs. Ornamental Woods. Drugs and Medicines, etc. etc.
  - Animals — Wild. Domestic.

CIVIL GEOGRAPHY.

1. Civil Divisions. { Empire, Kingdom, Republic, Duchy, etc., / State, County, Town, City, Village, etc.

2. Races. { 1. Caucasian. / 2. Mongolian. / 3. Malay. / 4. American. / 5. African. } Number and locality } of each.

3. State of Society. { 1. Savage. / 2. Barbarous. / 3. Half Civilised. / 4. Civilised. / 5. Enlightened.

4. Religion. { 1. Christians. { 1. Roman Catholic. / 2. Greek Church. / 3. Protestants. / 4. Nestorians and Armenians. / 2. Jews. / 3. Mahometans. / 4. Pagans.

5. Government. { 1. Patriarchal. / 2. Monarchy, { Absolute. / Limited. / 3. Aristocracy. / 4. Democracy. { Pure. / Representative.

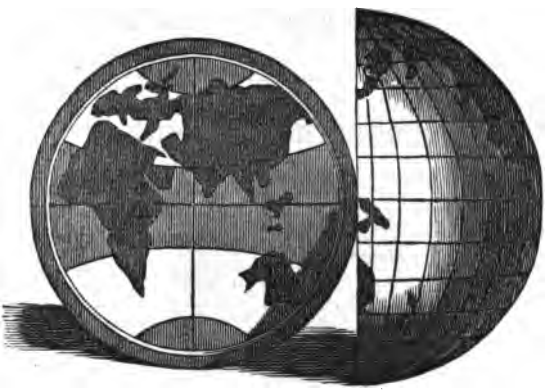
6. Science, Literature and Arts.

GEOGRAPHY.

Arrangement of Topics for the study of any Country, State, or Kingdom.

1. Boundaries?
2. Latitude and Longitude?
3. Surface?
4. Mountains?
5. Plains?
6. Islands?
7. Capes?
8. Bodies of Water?
9. Rivers?
10. Climate?
11. Soil?
12. Natural Curiosities?
13. Productions?
14. Exports and Imports?
15. Square Miles?
16. Population?
17. Race?
18. State of Society?
19. Capital?
20. Chief Towns?
21. Internal Improvements?
22. Education?
23. Religion?
24. Government?
25. Manners and Customs?
26. Language?
27. History?
28. Science, Literature, Arts?

HEMISPHERE GLOBE.



A globe, cut in equal sections and hung upon a hinge, when opened and the spherical side presented, helps scholars better to understand what is the true form of the earth, than they can possibly do by being told that the flat surface of a map represents something round like a ball.

By presenting the Hemisphere Globe opened in connection with hemisphere maps, the teacher can at once reconcile the difficulties of understanding how portions of land most remotely situated upon the extremities of the circular maps are to be considered as united with each other. By closing together the globe, all the relative positions of places are more clearly shown than they can be by the hemisphere maps.

The hemisphere globe, when opened and its spherical sides presented, gives a correct idea of the spherical form of the earth, and presents at one view its entire surface, without distorting the lines of latitude and longitude, as they necessarily are upon the map. It enables the scholar more readily to understand how that the four points marked as poles

on the circular maps, by closing the globe together, mean to represent but the two poles of the earth. It also brings together the lines of the Arctic and Antarctic Circles, showing their correspondence with the circles of the frigid zones.

TERRESTRIAL GLOBE.

A Globe should invariably precede the use of maps, to avoid the erroneous impression with children that the earth is flat, and the Hemisphere Globe should be used in connection with the Hemisphere Map.

For several reasons, a five inch Globe is preferable, in a common school, to one of any other size.

While it shows the spherical form as well as any other, and is large enough to give a distinct view of the principal divisions of land and water to all the members of any ordinary class in Geography, it is not so large but that it can be

held in the hand conveniently for familiar illustration; nor is it so large but that it can be made of solid, firm material, without too much increase of weight, which secures it against destruction in case of a fall.

Again, anything that is desirable to be taught by the use of a globe to an ordinary geography class, can be taught better with a small globe, elevated on a simple pedestal, or suspended by a cord, than by a large globe, costing ten or twenty times as much, surrounded and encumbered by a frame work, horizon and meridian, as such globes usually are.

The fact, that where both a large and small globe are in possession of teachers, the former is *showed* to visitors, and the latter *used* to instruct scholars, is a sufficient indication of the comparative utility of the two.

But an *outline* globe is preferable in primary instruction to one so much crowded with names as to render the forms of seas and continents obscure and incorrect. The details of particular countries are studied better on maps than on globes. If the minutiæ of Geography should be studied on globes, then ought globes to be large enough to embrace the details of countries and towns, which of course is impossible with any ordinary limits of expense.

APPLICATIONS.

I. THE SHAPE OF THE EARTH.

That the Earth is spherical, appears from the following proofs and illustrations:

Proof 1*st*. The Earth has been traveled around.

Illustration. A [redacted]y crawling around the globe, in any continuous direction, comes back to the starting point, so

travelers have passed around the earth in nearly all directions, and returned to their homes.

Proof 2*d.* The shadow of the Earth on the Moon is always circular.

Illustration. The globe always casts a circular shadow, whereas no other body, in all positions, will do so. Try a cylinder, a cone, oblate and prolate spheroids, and then the globe.

Proof 3*d.* The upper part of an approaching object is seen first, as a ship at sea.

Illustration. Insert a pin into the globe, and turn the globe. The outer extremity is first seen, when approaching, and disappears last when receding.

Proof 4*th.* A horizontal line diverges from any horizontal plane surface. The divergence is 8 inches for the first mile, 32 for two miles, 6 feet for three miles, etc.

Illustration. Apply a straight edge to the globe, and it is seen to coincide with it but a short distance.

Proof 5*th.* Vertical lines at any considerable distance from each other are not parallel, but diverge toward different parts of the heavens.

Illustration. Insert two or more pins, perpendicularly to the surface of the globe, at some distance from each other, and they are seen to diverge outward and to converge toward the center, *i. e.*, are not parallel to each other, as they would be if inserted perpendicularly into a plane surface.

Proof 6*th.* The North Star rises as we travel north, and declines as we go south till we reach the equator, when it disappears.

Illustration. The globe being on its stand, let the north pole be directed toward any small object, as a nail in the ceiling. If that nail represent the north star, and a short

pin a traveler, and the pin be moved from the pole toward the equator and across it, then will it appear that the globe will intercept the line of vision from the traveler to the star soon after crossing the equator.

Proof 7th. Analogy.

Remark. As all other bodies in the heavens are spherical, except Comets and Saturn's rings, it is reasonable to conclude that the earth is likewise a sphere.

Proof 8th. Were the earth ever a fluid, (and there is sufficient evidence to show this to be a fact,) the force of gravity would have compelled it to take the form of a sphere.

THE EARTH A SPHEROID.

That the earth is not a perfect sphere, but a spheroid, having the polar diameter shorter than the equatorial, appears from the following proofs:

Proof 1st. A pendulum vibrates more rapidly as it is carried from the equator toward either pole.

Remark. The frequency of the vibrations of a pendulum depends upon the force of gravity, and gravity varies as the squares of the distances from the center of the Earth vary inversely. Since then a pendulum vibrates more rapidly near the pole than near the equator, it is inferred that the surface at the pole is nearer the Earth's center than at the equator.

Proof 2d. A degree of latitude on the earth's surface, as indicated by the stars, is longer near the poles than near the equator, showing that the surface is there flattened.

Remark. By accurate measaurement of degrees in the torrid and frigid zones, the polar diameter is found to be twenty-six miles shorter than the equatorial diameter, or as 301 to 302.

Proof 3*d.* Were the Earth ever in a fluid state, the centrifugal force, arising from its revolution on its axis, would compel it to assume the form of an oblate spheroid.

II. MATHEMATICAL LINES AND DIVISIONS.

1. *Diameter.* Any straight line extending through the center of the earth from surface to surface.

2. *Circumference.* Greatest distance around the earth.

3. *Axis.* That diameter about which the earth revolves. (*Poles.* The extremities of the axis.)

4. *Great Circles.* Any circle which divides the earth's surface into two equal parts.

5. *Small Circle.* Any circle which divides the earth's surface into two unequal parts.

6. *Equator.* The *great circle,* at equal distance from the poles.

7. *Tropics.* Two *small circles,* 23½ degrees from the equator.

8. *Polar Circles.* Two *small circles,* 23½ degrees from the poles.

7. *Meridians.* *Great circles* passing through the poles and the equator.

10. *Parallels of Latitude.* *Small circles* parallel to the equator, either north or south of it.

11. *Zone.* A belt or girdle, surrounding the earth.

Torrid Zone. That portion of the earth's surface between the tropics.

Temperate Zones. The two belts between the tropics and polar circles.

Frigid Zones. Those portions of the earth's surface included by the two polar circles.

Hemispheres. Any two equal divisions of the earth; as, northern and southern, eastern and western.

REMARK. All mathematical lines and divisions are imaginary.

Illustration. By the use of the globe, on which the imaginary circles are drawn, the other lines and divisions can be clearly pointed out and explained.

III. MOTIONS OF THE EARTH.

The two most important motions of the Earth, are the Diurnal Motion, or that around its axis, and the Annual Motion, or that in its orbit around the Sun.

ILLUSTRATION, 1. With the Globe on the stand, make it revolve on the inclination wire or axis. This will represent the diurnal motion. If it, at the same time, is carried around any object representing the Sun, it will illustrate the annual motion.

2. The better method of combining these motions is to suspend the Globe by a cord, attached to a nail in the ceiling. By this means the elliptical form of the orbit may be shown, as well as the two motions combined.

IV. THE RELATIVE POSITION OF PLACES.

The true relative position of places is not shown on maps except in comparatively small areas, and the globe should be in the hand of the teacher of geography at every recitation, in order that scholars may obtain the true direction and approximate distance of every Country, State, or Town, from their place of residence and from each other.

Remark. It will be seen by the globe that any place, as San Francisco, may be said to be in three directions from any other place, as London. San Francisco can be reached

by traveling in a continuous line on the earth's surface, either S. W. or N. E., or by electricity, in a straight line through the earth. Asia is both East and West of America, likewise, on the opposite side of the earth.

From the relative position of places on the earth's surface, the inhabitants receive different relative appellations.

Antipodes are those living diametrically opposite. They have opposite seasons, and opposite days and nights.

Antœci are those living under the same meridian, but on opposite parallels of latitude. They have opposite seasons, but the same days and nights, though the days of one are equal always to the nights of the other, (disregarding atmospheric refraction of light.)

Periœci are those living on the same parallel of latitude, but under opposite meridians. They have the same seasons, but opposite days and nights; *i. e.*, when it is noon with one, it is midnight with the other.

V. NO ABSOLUTE UP AND DOWN.

Remark. *Up* and *down* are merely relative terms, used in connection with direction to or from the earth's center. With respect to the stars or space at large, that direction which we call *up* at midday is *down* at midnight. And at any time, that direction which is *up* to any person on one side of the earth, is *down* to any person on the other side.

Illustration, 1. Insert a pin into the globe and turn the globe on its axis. It will be seen that the direction which would be called *up* by a person similarly situated on the earth is constantly changing.

Illustration, 2. Insert two pins at antipodes, as in America and Asia. It will be seen that the heads point in opposite directions, viz.: the direction which is *up* to one is *down* to the other.

VI. PHENOMENA.

Succession of Day and Night.

Day and night are caused by the revolution of the earth on its axis, bringing any place between the two polar circles once in the light of the Sun at each revolution.

Illustration, 1st. In a darkened room, having in it only one lighted candle, it will be seen that one-half the surface of the globe is illuminated and the other half is in shade Insert a pin at your place of residence, and turn the globe on its axis. It will come round alternately into light and shade, or into day and night.

Illustration, 2d. By daylight, a window or any other object may be taken for the Sun, and the imagination can picture the illumined hemisphere on the side toward the supposed Sun; or the large ball of the lunarian can be used in connection with the globe.

The Change of Seasons.

The change of seasons is produced by the inclination of the earth's axis to the plane of its orbit, as shown by the inclination of the axis of the globe.

Illustration. The change of the seasons may be shown by carrying the globe, with the axis continually directed toward the north, about any object assumed as a Sun.

Trade Winds.

The trade winds are caused by the revolution of the earth on its axis from west to east, in connection with the current of air flowing toward the equatorial region to supply those portions of space from which the air rises by the action of the Sun's heat.

Illustration. (With the globe in hand.) It is supposed that,the Sun is shining directly on the equator. Those parts of the earth's surface about the equator, being much heated, rarefy the air in contact with them. The air thus rarefied rises; other air from the north and south, within and beyond the tropics, flows in to supply the place of the air so elevated. But as the atmosphere partakes of the motion of that part of the earth's surface with which it is in contact, and as the surface at the tropics and beyond them does not move as rapidly from west to east as at the equator, since those circles are smaller than the equator, it is plain that if air with the eastward motion of the tropics, say 900 miles an hour, were instantaneously transported to the equator, where the eastward motion of the earth's surface is 1,000 miles an hour, the air so transported would have a relative backward or westward motion of 100 miles an hour. But as it is not transported instantaneously, but flows with a moderate velocity, its westward motion, though considerable, is not so great. It must be remembered that the motion toward the equator is combined with the backward or westward motion, giving the trade winds a south-westerly direction north of the Sun, and a north-westerly direction south of the Sun. When the two currents meet, which is always a few degrees behind the Sun, in its course from one tropic to the other, they combine and form a westerly current.

VII. ABSOLUTE AND RELATIVE TIME.

It is considered 12 o'clock, M., at any place on the earth's surface when the sun is on the meridian of that place.

But as the sun has an apparent motion from east to west of 15 degrees an hour, or 360 degrees in 24 hours, evidently, it cannot be 12 o'clock at the same time, at any two places not on the same meridian.

Then at any place, as Boston, lying on a meridian east of any other place, as New Orleans, it must be 12 o'clock, or noon, before it is noon at the latter place, because the sun will reach the meridian of Boston sooner, in its westward course, than it will the meridian of New Orleans.

Hence, if it is noon at Boston, it will be forenoon at New Orleans, and if it is noon at New Orleans it will be afternoon at Boston. While then absolute time is the same in all places, relative time is later at places lying east of us, and earlier at places lying west of us.

Illustration. Insert a pin at Boston, another at New Orleans, assuming any object on a horizontal line with the globe for a sun. Turn the globe on its axis, from west to east, it is seen that the pin at Boston comes under the assumed sun before the pin at New Orleans.

VIII. MEASUREMENT OF DISTANCES.

Take a narrow tape, and make it the same length of the equator on the globe. Divide by folding into 5 equal parts. Mark with pencil or pen these divisions. In the same manner subdivide these divisions into 5 other equal parts. Call each 1,000 miles. Again divide these as many times as convenient.

A scale is now made by which distances, from place to place, may be ascertained, the comparative length of different routes and voyages known, etc. These, as fast as ascertained, should be committed to memory, or written down for future reference. This is found to be an amusing and instructive exercise, valuable in family or school, to keep children out of mischief, and to imprint on their minds some of the most important geographical knowledge.

QUESTIONS ON THE GLOBE FOR PRIMARY SCHOLARS.

Shape of the Earth.

What does the Globe represent? The Earth in which we live. Is the Earth then round like a ball, or round like a plate? What other names are there for a ball? Sphere and Globe. What is the difference between a ball and a sphere? Ans.—A sphere is exactly round, and every point on the surface is equally distant from the center. A ball is not always an exact sphere, but nearly so.

Is the Globe an exact Sphere?

How do we know that the Earth is round like this Globe? Ans.—By sailing around it.

Do you know any person that has sailed around it?

What other reasons lead us to think the Earth round like this Globe? (*The answer may be obtained from the book, with the methods of illustration.*)

Is the Earth a Sphere or a Spheroid? A Spheroid. Why is it called a Spheroid? Because Spheroid means like a sphere. Here the Sphere and Spheroids should be used to show the difference of the two kinds of Spheroids and the Spheres. The Globe is an oblate Spheroid, being one-eighth of an inch thicker one way than the other.

How do we know that the Earth is an oblate Spheroid? (*For answer, refer to the section, "The Earth a Spheroid."*)

Size of the Earth.

How large is the world which we call the Earth? Answer. 25,000 miles around and 8,000 miles through. What is the distance around called? The circumference. What is the distance through called? The diameter. Has the Earth more than one diameter? It has many. How much longer

is the longest diameter than the shortest? Twenty-six and one-half miles.

Lines and Divisions of the Earth.

Where is the equator on the globe? (Let the scholar find it.)

Is the equator a diameter or a circumference? A circumference.

You see some lines crossing the equator and meeting at the top and bottom of the globe. What are they called? Meridians.

What are the places called where those meridians meet? Poles.

What is a line running through the earth from pole to pole called? Axis.

Why? Because the earth revolves around that line as a wheel around an axle.

Is the axis a circumference or a diameter? A diameter. Is it the longest or shortest diameter? The shortest. Where is the longest diameter? Through the equator. Why is the equatorial diameter longer than the poles? Ans.—Because in consequence of its rotation, the earth bulges out at the equator and is drawn together at the poles.

What are those lines called, passing around the globe, parallel to the equator above and below it? Parallels of latitude.

How far apart are they drawn? Ten degrees. Are these the only parallels on the earth's surface? No. There is a parallel of latitude passing through every place north or south of the equator.

Are these lines real or imaginary on the globe?

Are they real or imaginary on the earth?

You see two dotted parallels, between the second and

third, north and south of the equator. What are they called? Tropics.

Why are they called tropics? Because the sun does not go further from the equator than these lines. That is, the sun is never overhead at any place beyond these lines, either north or south of the equator.

How far are the tropics from the equator? Twenty-three and a half degrees. How much is a degree? Sixty-nine and a half miles.

You notice some dotted lines around the poles. What are they called? Polar circles.

How far are the polar circles from the pole? Twenty-three and a half degrees.

What is a Zone? A belt or girdle.

What is the zone lying between the tropics called? Torrid. Why? It is very hot, in consequence of the sun's shining more directly on the earth there than elsewhere.

What two zones are those lying between the tropics and polar circles? The Temperate Zones. Why? Because the climate in these zones is neither so hot as in the Torrid Zone, nor so cold as about the poles.

What are those two zones about the poles called? Frigid.

Why? Because they are frozen during the greater part of the year.

How far do they extend? From the poles to the polar circles.

PHYSICAL DIVISIONS.

Land.

I will point out to you the great divisions of Land and Water. Can you tell by the globe whether there is the most land or most water on the earth?

What are these great divisions of land called? Conti-

nents. How many continents are there? Two, Eastern and Western. What countries are there on the Eastern Continent? Asia, Europe, and Africa. What countries on the Western Continent? North America and South America. What are the smaller portions of land called? Islands. Which is the largest island? N. H.

What continent do you live on?

What country do you live in? What State? What Town?

Water.

What are the largest divisions of water called? Oceans.

What oceans are there on the globe? A., P., I.

What are the smaller divisions of water called? Seas, bays, gulfs, rivers, etc.

Which is the largest sea? M.

Between what countries is the Pacific Ocean?

Between what countries is the Atlantic?

Between what countries is the Mediterranean Sea?

Which side of the equator is Australia? What islands north of Australia? New Guinea, Borneo, and Sumatra. Is Sumatra east or west of Australia? West. Which way from Borneo? West.

What large island east of Africa? Madagascar. In which hemisphere? Southern.

Which tropic passes through Australia and Madagascar? Capricorn. Are Borneo and Sumatra in the northern or southern hemisphere? Both. Which side of the equator is New Guinea? South.

Is the Mediterranean north or south of Africa? North. Which way from Europe? South. From Asia? West. Is the Caspian Sea in Europe or Asia? Asia. Which way from the Mediterranean? East. Which way from the

Caspian, also from the Mediterranean, is the Black Sea? West of the Caspian, and north of the Mediterranean.

Is the Gulf of Mexico east or west of America? East. Which way from South America? North. From North America. South. In the northern or southern hemisphere? Northern. North or south of the Tropic of Cancer? Both. Is Baffin's Bay in North or South America? North. Which side of the northern polar circle? South.

Are the West India Islands east or west of the Gulf of Mexico? East. Which of the West India Islands is largest? Cuba. Which tropic passes through Cuba? Cancer. Are the Sandwich Islands east or west of America. West. In the Atlantic or Pacific Ocean? Pacific. North or south of the equator? North. Are the Society Islands north or south of the Sandwich Islands? South. In which hemisphere? Southern. Which side of the Tropic of Capricorn? North.

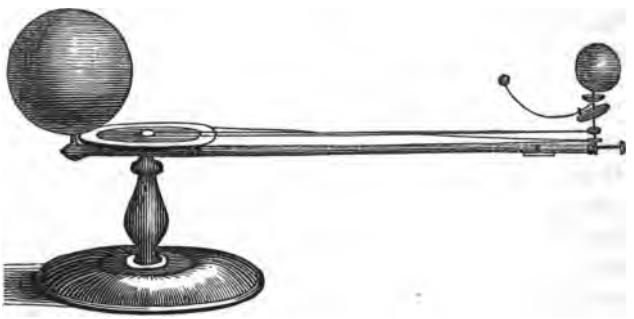
In what country do you live? The United States of America. In North or South America? North. In which continent? Western. If you were going from the United States to Europe, what ocean would you cross? Atlantic. Would you go east or west? East. If you were going to Africa, would you go north-east or south-east? South-east.

If you were going to Cape Horn, would you go north or south? South. Which way to Cape of Good Hope? South-east. Are those two capes in north or south latitude? South.

Where does tea come from? China. Where is China? In Asia. What else comes from China? Silks and China-ware, or porcelain. How do ships get to China? Go through the Atlantic, and double the Cape of Good Hope or Cape Horn. In going to China by the Cape of Good Hope, do ships go through the Indian or Pacific Ocean? Indian. By way of Cape Horn, what ocean do they pass?

Pacific. Is China in the northern or southern hemisphere? Northern. In going for a cargo of tea, do our ships sail in the northern or southern hemisphere, or both? Both. In making a voyage, how many times does she cross the equator? Four times; twice in going and twice coming. In going to China through the Indian Ocean, what large islands are passed? Sumatra and Borneo. Which way are those islands from China? South. In what part of the Indian Ocean is the island of Madagascar? The western. Which tropic cuts it? Capricorn. What other land is cut by that tropic? Africa, South America and Australia. In which hemisphere is New Zealand? Southern. Which side of the tropic of Capricorn? South. What countries does the tropic of Cancer cut? China, Hindostan, Arabia, Africa, and Mexico. What seas or gulfs are cut by this tropic? The Gulf of Mexico, Red Sea, and Persian Gulf.

THE TELLURIAN.



This instrument is designed to illustrate all the phenomena resulting from the relations of the Sun, Moon and Earth to each other. The most important of these phenomena are the succession of day and night, the change of seasons, the change of the sun's declination, the different lengths of day and night, the rising of the sun north of east in summer, the changes of the moon, solar and lunar eclipses, spring and neap tides, the later daily recurrence of the tides, the length of days on the moon, the appearance of the earth to observers on the moon, the harvest moon, the difference of a synodical and sidereal revolution of the moon, the precession of the equinoxes and the difference of a solar and sidereal year. All these phenomena may be explained by the use of the Tellurian, with a clearness and simplicity that bring them within the comprehension of a child. Before passing to an explanation of the manner in which they may be illustrated, I shall describe the construction of the instrument, and give directions for its adjustment.

CONSTRUCTION.

The Tellurian, as seen by the cut, consists of the stand *a*, the arm *b*, the three fixed pulleys *c*, the handle *d*, the three movable pulleys *e*, the inclination wire *f*, the moon's orbit plane *g*, the extension screw *h*, and the three balls representing the Sun, Earth, and Moon. Of these three balls the globe is three inches in diameter, the small ball seven-eighths of an inch, giving nearly the true proportionate size of the moon; and the large ball five inches, the true proportionate size of which would be nearly twenty-eight feet. The proportionate distance of the moon from the earth would be seven and a half feet; while the earth should be placed at the distance of two thousand nine hundred and sixty-nine feet from the sun. It is perceived that an instrument giving the true proportionate sizes and distances could not well be constructed; and were it constructed, would require either a telescope or microscope to examine it. Notwithstanding the proportions are not preserved in the Tellurian, the causes of the various phenomena appear much more clearly than if they were.

Of the three fixed pulleys, only the upper and larger one is seen in the figure. There are three corresponding movable pulleys on the end of the arm, each moving independently of the other. The upper pair of pulleys, one movable and one fixed, being connected with a cord passing around both, serve to give motion to the moon around the earth. The middle pair, connected by a cord in a similar manner, give a slow motion to the moon's orbit plane. The lower pair, being both of the same size and connected by a cord, preserve the parallelism of the inclination wire or axis of the earth.

The extension screw is for the purpose of tightening the cords when they become slack by use.

ADJUSTMENT.

In setting up the instrument, screw the upright standard, to which the arm and fixed pulleys are attached, into the circular base; place the movable pulley, with the orbit plane, on the wire at the end of the arm; arrange the cords around the respective pairs of pulleys, crossing the cord which goes around the upper pair, (this is the longest cord of the three;) place the globe on the inclination wire and the sun or large ball on the wire in the handle; then turn the stand so that the dividing line, between Aries and Pisces, on the horizontal circle on the large fixed pulley, shall be on the east side of the center; again, by applying the thumb and finger to the lower movable pulley, turn the inclination wire and globe on it, so that the north pole of the globe shall be directed toward the north star. The instrument is now adjusted.

If by means of the handle the arm is turned around, it will be observed that the sun and earth revolve around a common center of gravity; that the sun revolves on its axis by coming in contact with the large pulley; that the moon revolves around the earth thirteen times while the earth goes around the sun once; that the parallelism of the earth's axis is maintained always pointing toward the north. The revolution of the earth on its axis is effected by striking the globe lightly with the finger. The motion of all the balls should be from west to east in the southern part of their orbits.

DAY AND NIGHT.

The succession of day and night is best represented by placing a short lighted candle on the center of the large

fixed pulley, in a darkened room. Half of the globe will then be seen to be in light and half in shade. Insert a small pin at your place of residence on the globe, as nearly as may be, and turn the globe on its axis with the finger, from west to east on the south side. It will be noticed that the place thus designated is alternately in light and shade, or in day and night. And if the pin is supposed to be an observer, it will see the sun coming into view, or rising over countries or seas at the east, and passing around over its meridian, disappearing or setting behind countries and seas lying in the west.

The succession of day and night is thus represented as it actually appears to an observer beyond the earth's orbit; say at Mars or Jupiter.

VARIATION IN LENGTH OF DAY AND NIGHT.

If the arm of the Tellurian, adjusted as already explained, be turned so as to bring the globe directly west of the yellow ball or sun,* both poles will be illuminated by the light of the candle, as if proceeding from the Sun, and all parts of the globe, excepting the poles, will come successively and equally into light and shade, when it is made to revolve equally on its axis. At this point then in the earth's orbit, as well as at the opposite point, the days and nights will be equal all over its surface. Hence, the east and west points of the Earth's orbit are called by astronomers equinoctial points or equinoxes, from *equas*, equal, and *nox, noctis*, night.

But as the earth passes on in its orbit from the western equinox toward the south, since the axis continues directed

* When the words *Sun*, *Earth*, and *Moon*, begin with capitals, they refer to the bodies in the heavens, but when they begin with small letters, they refer to the balls which represent them on the Tellurian.

toward the north, the light will gradually extend over the north pole and recede from the south pole. The northern hemisphere will thus become more than half illuminated, and the southern proportionally less. Now, it will be perceived that any place north of the equator will remain longer and longer in light at each diurnal revolution as the earth advances, until it arrives at the southern point of its orbit. Here the light will extend over the north pole twenty-three and a half degrees, and fall as far short of the south pole, giving the longest possible day to the northern hemisphere, and the shortest possible night; but in the southern hemisphere the shortest day and the longest night.

Notice, too, that all places north of the Arctic Circle will make more than one entire revolution in light, and thus have a day of more than twenty-four hours in length.

Again, turn the arm and carry the globe through the northern part of its orbit, it will readily appear why the inhabitants of the northern hemisphere have nights longer than days in that part of the earth's orbit.

That both poles must have days and nights of six months each, is also apparent.

THE CHANGE OF SEASONS.

The inclination of the earth's axis, together with its parallelism, influences more or less all terrestrial phenomena. The attentive pupil must have already seen that the variation in the length of day and night is the result of this cause. If so, he is prepared to understand in what manner the change of seasons is brought about by the same means.

Let the arm of the Tellurian be directed toward the south, then the earth's axis will be inclined toward the sun, and a line extending from the earth's center to the sun's center, will pass through the tropic of Cancer. Hence, an observer

on that tropic would, at noon, see the sun directly overhead when the Sun and Earth are in this position with regard to each other, and all the inhabitants of the northern temperate and frigid zones would see the sun at its greatest altitude. This must be midsummer, or as it is termed by astronomers, the summer solstice. Observe that the longest day occurs at this time in the northern hemisphere, and that the sun is more nearly vertical when on the meridian at all places north of the tropic of Cancer than at any other time of the year; *i. e.*, the sun shines a larger portion of the twenty-four hours on this part of the earth's surface, and emits a larger amount of rays on any given space than at any other time.

Now, move the arm around toward the east, as the inclination of the axis continues toward the north, it becomes less and less inclined toward the sun as the earth moves on to the eastern part of its orbit. Being at the eastern point, it is neither inclined to nor from the sun, but the extremities or poles are equally illuminated. As before shown, this is one of the equinoxes, and as it succeeds summer, it must be the autumnal equinox. The sun is now vertical at the equator; in other words, "is crossing the line."

Again, turn the arm toward the north—observe that the north pole is carried into darkness, while the south pole is brought more and more into light. If the earth has reached the north point of its orbit, the axis is inclined away from the sun, and the southern hemisphere is more directly under its influence. The sun will now be vertical at the tropic of Capricorn, and shine a longer portion of the twenty-four hours on the southern hemisphere, and with greater intensity, while the days are shorter, and the rays more oblique on the northern hemisphere than at any other time of the year. Here, then, must be the winter solstice to the inhabitants of the northern hemisphere.

Carry the arm around toward the west, at the same time

make the globe revolve on its axis; observe that the days become longer and longer in the northern hemisphere, while the earth is prosecuting this part of its annual journey. The globe having arrived at the west point of its orbit, occupies the same relative position with regard to the Light as the Earth with regard to the Sun, at the vernal equinox. The sun is now visible at both poles, and is again crossing the line.

Thus having followed the round of the seasons, we can not but admire the simplicity of the mechanism which produces such varied and beautiful results. Were the axis perpendicular to the plane of the orbit, there could be no change of seasons, but unvarying arid heat would prevail in the equatorial regions; while perpetual frosts would reign over a much larger portion of the Earth's surface than under the existing arrangement.

The tropics, so called, because at these lines the sun turns back towards the equator, depend for their locality upon the axial inclination, being necessarily as many degrees from the equator as the axis is inclined from the perpendicular. Were the axis to lie down on the plane of the orbit, the tropics would be in the poles, and the polar circles at the equator.

Rising and Setting of the Sun north of the east and west points of the horizon.

Since the sun never comes further north than the tropic of Cancer, how is it, that morning and evening, even in our latitude, it casts its rays on the north side of our dwellings and other objects during the summer months?

In order to understand this the more readily, let us consider the appearance of the sun at the poles. About the 20th of March it begins to make its appearance, gradually

rising into view as it makes the entire circuit of the horizon every twenty-four hours. Higher and higher it rises, passing around the heavens, almost entirely parallel with the horizon, until, at midday, corresponding to our midsummer, it reaches the altitude of twenty-three and a half degrees, and from that time winds downward, and in three months is lost again behind the continent of ice.

At any place within the Arctic Circle, once in the year at least, the sun will be seen directly over the north pole, as can be shown by the globe of the Tellurian. Below the Arctic Circle and near it, the sun will be seen just dipping below the horizon, a few degrees west of the meridian, and soon emerging as many degrees east of it. The farther south the observer is situated, the longer will the sun continue below the horizon, and the nearer will it rise and set in the east and west points of the heavens; in other words, the further north he is situated, the nearer will it rise and set to the north point of the horizon.

SIDEREAL AND SOLAR DAY.

While the earth is revolving on its axis, it is likewise revolving around the sun; hence, an entire diurnal revolution which brings any locality under the same star, will not bring it into the same relation to the Sun.

Let the arm of the Tellurian be directed toward the north; insert a pin at any point on the equator of the globe; let the pin be directed toward the sun, (yellow ball,) which will be exactly south. Now turn the globe once on its axis, at the same time moving the arm forward a short distance toward the west. When the pin is brought around again toward the south, it is not directed toward the sun as before, but must make a part of another revolution to come round in the direction of the sun. The first is the sidereal, the

second the solar revolution or day. There will, of course, be one more sidereal revolution than solar in a year, however few or many there may be of either, unless the revolutions are in opposite directions, when there will be one less.

REVOLUTIONS OF THE MOON.

The Moon has at least three revolutions: the first on its axis, the second around the Earth, the third around the Sun.

The Tellurian represents the Moon as presenting always the same side to the Earth. This is true to nature, and it gives the moon one revolution on its axis for each revolution around the Earth, as, obviously, all sides of the moon will be brought successively under the eye of an observer situated beyond the moon's orbit. The fact of one side being presented always to the Earth has been attributed to the greater specific gravity of that side, making it hang down toward the Earth.*

CHANGES OF THE MOON.

The changes of the moon are the result of its opacity and its revolution about the Earth. We have new and full moon once in twenty-nine and a half days, from the fact that its revolution around the Earth once in twenty-eight days, in connection with the common motion of these bodies around the Sun, bring them all into the same relation with regard to each other in that period of time. This period is called a *lunation* or *lunar month.*

NOTE.—The difference of a sidereal and a synodical revolution can be shown in a manner similar to that of illustrating the difference of a sidereal and solar day.

Placing a strong light on the Tellurian, as before, turn the arm so as to bring the moon between the sun and earth. Evidently the dark side of the moon is now toward the Earth, and this is the position of the three bodies at *new moon*. Thus situated, the Sun and Moon are said to be in *conjunction*.

Turn the arm again, and bring the moon around on the side of the Earth opposite the sun. The illuminated side of the moon is now presented to the Earth. This is *full moon*, and the Sun and Moon in this position are said to be in *opposition*. As the Moon's orbit is not on the same plane with the Earth's orbit, the Moon is sometimes above and sometimes below the plane of the Earth's orbit or *ecliptic* at new and full. Hence we do not always see exactly the same hemisphere at full moon, or the crescent pointing in the same direction at new moon. The horns of the crescent will however always point away from the sun whether above or below, or as we say the moon *runs high* or *runs low;* all of which can be clearly shown by the Tellurian.

The intermediate phases, as the quadrants and octants, are also seen by the Tellurian, but perhaps more clearly by the use of the Lunarian.

ECLIPSES.

An eclipse is nothing more than an obscuration of the Sun or Moon by the obscuration of the Sun's rays.

An eclipse of the Sun or a *solar eclipse* is shown by turning the Tellurian arm until the moon casts a shadow on the earth's surface. An eye situated at the place of the shadow could not of course see the luminous part of the candle. So on the earth's surface, wherever the shadow of the Moon falls, the Sun can not be seen, as it is in an eclipse. A solar eclipse commonly happens at new moon, and can be *total*

when the Moon's center is in or very near the ecliptic, or when the moon is at one of its *nodes*. Since, as shown by the Tellurian, the Moon is sometimes above and sometimes below the ecliptic at this period, it is obvious that an eclipse can not happen at every new moon.

A *partial* eclipse will occur wherever a part of the Sun's disk is obscured by the intervention of the Moon.

A lunar eclipse is shown by turning the Tellurian arm until the moon comes into the shadow of the earth, either partially or entirely; giving a partial or total eclipse. Neither of these can happen at every full moon, in consequence of the obliquity of the Moon's orbit to the ecliptic. The construction of the instrument is such that the moon's orbit plane will come into the same relation to the earth's plane once in eighteen revolutions of the earth around the sun. This arrangement corresponds to the Chaldaic period in nature, which gives the recurrence of nearly the same order of eclipses once in eighteen years and ten days. By means of this period, the ancients were enabled to foretell eclipses, but with no great degree of precision.

TIDES.

Tides are the result of the unequal attraction of the Moon on the water on the Earth's surface, and on the inflexible mass of the Earth itself. They are influenced likewise by the Sun, and by the form and position of coasts and harbors.

Since the water under the Moon is 4,000 miles nearer to it than the center of the Earth, it will be attracted by as much greater force than the Earth as the square of 240,000 is greater than the square of 236,000. Hence the water is heaped up under the Moon, and this elevated mass of water will pass around the earth as far as continents will permit, once in twenty-four hours, or as often as the Earth revolves

under the moon. This will account for a tide once a day. But there are two tides daily. How is this?

Since the water on the side of the Earth opposite the Moon is as much more distant from the Moon than the center of the Earth, as the center of the Earth is than the water on the same side with the Moon, it must be attracted by a force as much less than is that by which the Earth is attracted, as the Earth is, than the water on the same side with the Moon. And as the water under the Moon is drawn away from the Earth, so the Earth is as much drawn away from the water on the side opposite the Moon. Hence, there will be a tide opposite the Moon as well as under it, and the two tides will be equal, or nearly so. This will give any place within the reach of tide water two tides in a day.

LATER DAILY RECURRENCE OF TIDES.

Tides happen about fifty minutes later every day, in consequence of the motion of the Moon in its orbit around the Earth.

This may be shown by giving motion to the Tellurian arm, and the globe on its axis at the same time. Observe that any place on the Earth must make more than an entire revolution to come around the second time under the moon, whereas if the moon were stationary, then a complete revolution would bring the same meridian again under it.

SPRING AND NEAP TIDES.

It is found by observation, that the influence of the Sun on the tides is about one-fourth as great as that of the Moon.

By the Tellurian it is shown that when the Sun and Moon are either in opposition or in conjunction, their influences

combine to produce a tide equal to the sum of the tides they would produce separately. This is called a spring tide, and will happen either at new or full moon.

Again, it is shown that when the Moon is at its quadratures, the tide will be equal to the difference of the Sun's and Moon's tides separately. This is called the neap tide.

The highest tide possible at any given place, will happen under the concurrence of the following circumstances, viz.: The Earth in its perihelion, the Moon in its perigee, at one of its egzegris, and in the zenith or nadir.

PRECESSION OF THE EQUINOXES.

The precession of the Equinoxes is the recurrence of the Equinoxes or any other period of the year before the Earth has made an entire revolution around the Sun.

It is found that a year is twenty minutes and seventeen seconds less than the time required for an entire revolution. This is occasioned by a change, not on the inclination of the Earth's axis, but on the direction of that inclnation. To show this clearly, take hold of the lower movable pulley with the thumb and finger and turn that pulley half the way round. In so doing you will cause the axis of the Earth to point south instead of north, but with the same inclination still. In nature it requires 12,934 years to make the change, and 25,868 years to bring the axis back again into its present position. Now if you start the arm from the east, where the globe will be in the position of the autumnal equinox, and while you turn the arm, you at the same time turn the axis so that it shall incline easterly, you have only to carry the arm around to the south to bring the globe into the position of the autumnal equinox again; *i. e.*, a quarter of a revolution of the axis produces a precession of the equinox—equal to a quarter of the Earth's orbit. The precession, then, we

see, is equal to the part of a revolution that the axis makes. It really makes a change of 50 1-10 in a year, and the precession is the same, and it requires twenty minutes and seventeen seconds for the earth to pass that part of its orbit. Hence, as before stated, the year is so much less than the time required for an entire revolution.

NOTE TO THE TELLURIAN.

Although the description of the uses of the Tellurian supposes a darkened room and a lighted candle placed on the instrument, these are by no means indispensable. The appearance that the globe and the small ball present when placed in such circumstances are very readily conceived by the youngest Geography scholar, when his attention is properly directed to the subject; and the fact, too, that the illumined hemispheres are always toward the light. The ball of the Lunarian, which is painted half black and half yellow, may be used in connection with the Tellurian, by daylight, to aid the imagination of scholars in getting a distinct conception of the illumination of half the balls representing the Earth and Moon.

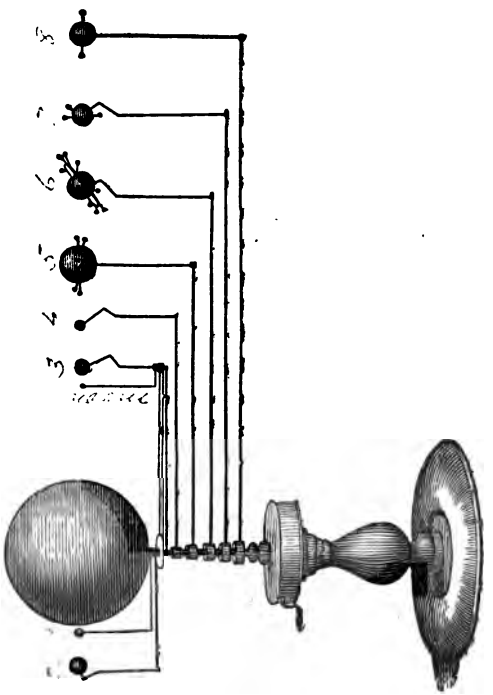
GEOLOGY.

Simplicity and vastness mark the works of God. In Geometry, an equilateral triangle, so simple that a child of five years can not only learn, but form and combine it, is also so vast, varied and rich in its applications to the works of nature and art, as to require a whole life of diligent research, to learn all its relations.

The outlines of Geography are far more simple and readily learnt, than the letters of the alphabet; yet, in the relations of this science to history, the Bible, commerce, the arts, national governments and character, missionary operations, the productions of the three great kingdoms of nature, climate, meteorology, topography, geology, and other subjects of useful knowledge, it is exhaustless, and has always the freshness of a new subject.

In Geology, ten simple minerals, called the Geological Alphabet, which can be learnt by a child of three years, in a week, or a day, are the elements of our globe, and give character to the towering mountain, the lofty precipice, the fertile valley, and the sparkling crystal. They also furnish a field of knowledge so vast, so rich and wonderful, as to require the laborers spending their lives in it, to divide it into many apartments, each one taking one small section.

When the different sciences are seen, in their relations to each other, their beauty, vastness and grandeur are greatly enhanced, while their simplicity remains unimpaired. This is pre-eminently the case with the three sister sciences of our earth—Geography, Geology, and Geometry. Indeed, a knowledge of either must be radically defective without an acquaintance with the other two. Hence, in connection with a globe, maps, diagrams, solids, albums, &c., is a Geological Cabinet, so simple and comprehensive, as to enable a person, in a few days, to be able to recognize the rocks, and many of the useful minerals, in any part of the globe he may visit.



THE PLANETARIUM.

THE PLANETARIUM.

In furnishing a brief manual to primary classes for the appropriate uses of this instrument, the science of Astronomy could not be presented in detail. A few of the elementary principles of the Solar System are referred to in connection with the Planetarium, designed to aid both teachers and scholars in better understanding those interesting truths, and which afford the student so great intellectual pleasure. All teachers feel the want of some instrument adapted to the capacity of common schools, which might divest this science of the mystery and discouragement hanging over it.

The Planetarium, or Orrery, represents the size and relative positions and annual revolutions of the Planets composing the Solar System, except the Asteroids.

The Solar System consists of the Sun and all the Planets and Comets that revolve around him.

1.

The Primary and Secondary Planets.

Question. How are the planets divided?

Answer. Into primary and secondary.

Q. Which are the primary planets?

A. 1st, Mercury; 2d, Venus; 3d, The Earth; 4th, Mars; 5th, Jupiter; 6th, Saturn; 7th, Herschel; and 8th, Leverrier.

Q. What are the secondary planets usually called?

A. They are called satellites or moons.

Q. Which are the interior planets, and why so called?

A. Mercury and Venus, because they revolve within the Earth's orbit.

Q. Which are the exterior planets?

A. Mars, the Asteroids, Jupiter, Saturn, Herschel, and Leverrier.

Q. What are the Asteroids?

A. The Asteroids consist of about twenty small solar bodies, which revolve between the orbits of Mars and Jupiter.

2.

Distances of the Planets from the Sun.

Question.—What are the relative distances of the planets from the Sun?

Answer.

Mercury	37	millions of miles,		Jupiter	495	millions of miles.	
Venus	69	"	"	Saturn	900	"	"
Earth	95	"	"	Herschel	1,800	"	"
Mars	145	"	"	Leverrier	2,800	"	"

Q. Can we easily conceive of such vast distances?

A. We can not without the aid of some illustration.

Q. How long would it take for a train of cars to pass from the Sun to Mercury at 30 miles per hour?

A. In 152 years.

Q. To the Earth?

A. In 361 years.

Q. To Herschel?

A. In 6,933 years.

Q. To Leverrier?

A. In 10,650 years.

Q. Would the Sun appear smaller to an observer at the planet Herschel than at the Earth?

A. It would, on account of its greater distance.

3.

Relative Size of the Sun and Planets.

Question. How much larger is the Sun than the Earth?

Answer. It is one million four hundred thousand times larger.

Q. How much larger is the Earth than Mercury?

A. It is seventeen times larger.

Q. How much larger is the Earth than Venus?

A. It is one-tenth larger.

Q. How much larger is the Earth than Mars?

A. It is six times larger.

Q. How much larger is Jupiter than the Earth?

A. It is one thousand four hundred times larger.

Q. How much larger is Saturn than the Earth?

A. It is one thousand times larger.

Q. How much larger is Herschel than the Earth?

A. It is ninety times larger.

Q. How much larger is Leverrier than the Earth?

A. It is ninety times larger.

4.

The times in which the Planets revolve around the Sun.

Question. How long are each of the Planets in revolving around the Sun?

Answer. Mercury in 0 years, 88 days.
Venus " 0 " 225 "
Earth " 0 " 365 " 6 h. 11 m. 11 s.
Mars " 1 " 322 "
Jupiter " 11 " 317 "
Saturn, " 29 " 175 "
Herschel " 84 " —
Leverrier " 164 " —

Q. Do all the planets move with the same velocity?

A. No, they do not.

Can you show by the Planetarium why Venus is seen alternately as morning and evening star?

5.

Hourly motion of some of the Planets round the Sun.

Question. How many miles does Mercury move per hour?

Answer. 95 thousand miles.

Q. The Earth?

A. 68 thousand miles.

Q. Saturn?

A. 22 thousand miles.

Q. Leverrier?

A. 11 thousand miles.

6.

Centripetal and Centrifugal Forces.

Question. What is meant by Centripetal Force?

Answer. It is the law of attraction by which the sun and planets are drawn toward each other.

Q. What is meant by Centrifugal Force?

A. It is that power which moves the planets onward in their course round the sun.

Q. What would be the result were the centripetal force suspended?

A. The planets would fly off in straight lines beyond their present orbits.

Q. What would be the result were the centrifugal force suspended?

A. The planets would yield to the centripetal or attractive force, and fall to the surface of the sun.

Q. Does not the fact of these two great laws, which govern the motions of the planets, display the wisdom of God?

A. It does, by steadily balancing the planets in their orbits at stated periods of revolution from age to age.

"Oh, Lord! how manifold are thy works; in wisdom hast thou made them all."

7.

Diurnal Revolutions of the Planets.

Question. Have the planets any revolution except around the sun?

Answer. They have; namely, the Diurnal or daily motion.

Q. What is the effect of the Earth and other planets from turning around their axes?

A. The recurrence of day and night.

Q. In what length of time do the planets revolve around their axes?

A.

Mercury	in 24 hours,	Jupiter	in 10 hours,
Venus	" 23½ "	Saturn	" 10½ "
Earth	" 24 "	Herschel	unknown,
Mars	" 24½ "	Leverrier	"

The Sun revolves around his axis in 25½ days.

Q. How is it ascertained that the planets have a diurnal revolution?

A. By observing the motion and direction of spots on their surfaces.

8.

The true form of the Planets.

Question. Are the planets exactly round, like a sphere?

Answer. They are not, being a little flattened at the poles.

Q. Where is their diameter greatest?

A. At their equators.

Q. How much greater is the diameter of the Earth at its equator than at its poles?

A. 26 miles.

Q. How much greater is the diameter of Jupiter at its equator than at its poles?

A. 6,000 miles.

Q. How much greater is the diameter of Saturn at its equator than at its poles?

A. 7,500 miles.

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